ASPECTS OF THE BIOLOGY OF *LIZA ABU* (MUGILIDAE) IN THE TIGRIS RIVER (TURKEY)

by

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ABSTRACT. - Sex distribution, growth in length and weight, relative condition index, attainment of first maturity age, and fecundity of *Liza abu* were examined in the Tigris River, South-eastern Anatolia. This species migrates towards upstream the Tigris River at a period extending from August to late February. The age of 480 specimens (263 females and 217 males) ranged between 1+ and 4+. The observed sex ratio was 1.21 female: 1 male in the studied samples. Allometric growth patterns was proved from the length-weight relationships. The female had high $L\infty$ (204.27 mm), but low K (0.304531) value whereas the $L\infty$ (195.77 mm) for male were lower, but the K (0.383129) value was higher. It was seen that relative condition index values from August and September were higher than those recorded at other times of the year. Spawning do not occur at this time in this area. According to development of gonad, male and female become sexually mature at the first year of their life-span. The smallest mature female was 117 mm in fork length and 17 g in total weight, while male was 115 mm in fork length and 14 g in total weight. The number of oocytes ranged from 12,175 to 56,400. Fecundity was significantly correlated with fish length, fish weight and gonad weight.

RÉSUMÉ. - Quelques aspects de la biologie de *Liza abu* (Mugilidae) dans le Tigre (Turquie).

La sex-ratio, la croissance (longueur et poids), le facteur relatif de condition, la maturité sexuelle et la fécondité de *Liza abu* ont été étudiés dans le Tigre, au sud-est de l'Anatolie. Cette espèce migre vers l'amont du Tigre d'août à la fin février. L'âge des 480 spécimens examinés (263 femelles et 217 mâles) variait entre 1+ et 4+. La sex-ratio observée était de 1,21 femelle pour un mâle. Le patron de croissance allométrique a été déduit de l'étude de la relation longueur - poids. Les femelles avaient une longueur maximale hypothétique plus importante ($L\infty = 204,27$ mm) que les mâles ($L\infty = 195,77$ mm) mais un coefficient de croissance plus faible ($K = 0,304531$, pour les mâles $K = 0,383129$). Les valeurs du facteur de condition étaient plus élevées en août et en septembre que pour les autres mois de l'année. Les poissons n'ont pas frayé dans les sites d'étude au cours de cette période. D'après le développement des gonades, la maturité sexuelle est atteinte chez les deux sexes au cours de leur première année. La plus petite femelle mature mesurait 117 mm (longueur à la fourche) et pesait 17 g (poids total) et le plus petit mâle mesurait 115 mm et pesait 14 g. Le nombre des ovocytes variait entre 12 175 et 56 400 et était significativement corrélé avec le poids des gonades, la longueur et le poids du poisson.

Key words. - Mugilidae - *Liza abu* - Turkey - Tigris River - Growth - Reproduction.

Liza abu (Heckel, 1843) is a mugilid species found in the Tigris and Euphrates River System. The species is one of the most common and best known of the mugilid fish from Iraq (Mahdi, 1967; Coad, 1980) and Syria (Beckman, 1962). The first record of *L. abu* for Turkish waters was reported by Kuru (1979) in the Khabour stream, branch of the

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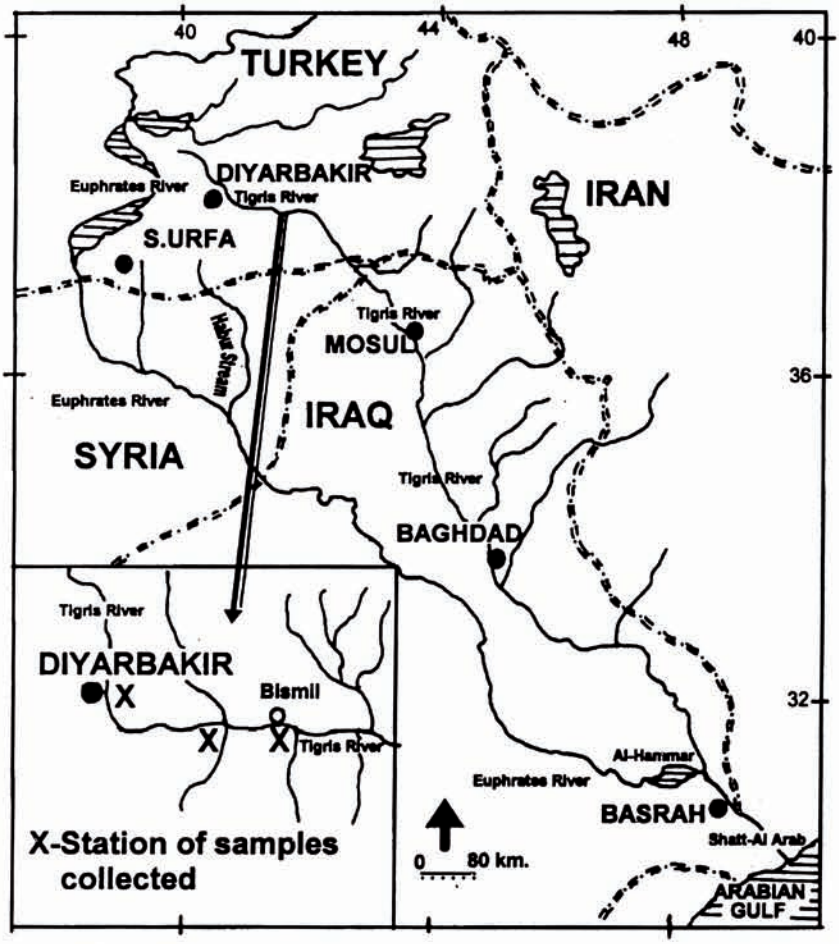

Fig. 1. - Map of study area.

Euphrates River, in Ceylanpinar. A few studies have been conducted on the meristic characteristics (Al-Hassan, 1984; Nasir and Naama, 1988), on biological aspects (Al-Nasiri and Sirajul Islam, 1978; Naama *et al.*, 1986; Al-Yamour *et al.*, 1988; Mhaisen and Al-Jaffery, 1989) and parasites (Mhaisen *et al.*, 1988) of this species in Iraq. The interest to study the biology of *L. abu* is that it is the only mugilid spawning in freshwater. It has been already reported that *L. abu* is spawning in Al-Hammar marsh, Iraq (Naama *et al.*, 1986) and in the Khabour stream, Syria (Beckman, 1962).

During our studies on the fish fauna of the Tigris River, numerous specimens of *L. abu* were caught from October 1990 to February 1992. To the best of our knowledge, this is the first record of *L. abu* from the Tigris River in Turkey.

The objectives of the present study were to determine the age, sex distribution, growth in length and weight, condition factor, attainment of first maturity age, and fecundity of *L. abu* in the Tigris River (Turkey).

STUDY AREA

The Tigris River originates as several conjoint streams in the tangled hill country of eastern Anatolia north of Diyarbakir city, Turkey, being fed by springs and by melt from snow. It then flows mainly South-eastward for about 1,900 km towards the Arabian Gulf, which it enters as a joint stream, the Shatt al Arab, with the Euphrates River. The Tigris River in Turkey is a typical mountain stream, flowing swiftly in a narrow, well-defined valley often slotted deeply into the surface, with gorges and rapids marking its course. For the rest of its course the river follows over a wide and gently surrounding Diyarbakir province. The sampling of *L. abu* was performed in areas located in the upper part of the Tigris River near Diyarbakir province in South-eastern region of Anatolia (Fig. 1). Fishes dwell in schools at the banks just under the water surface, in slow current water. The aquatic vegetation is rich in the bank of these places. Water levels at the upper part of the Tigris River are low during most of the year, except in spring. During the sampling period (between August and February), the minimal and maximal water parameters were determined as follows; temperature 12-25°C, dissolved oxygen 5-8 mg/l, pH 7.8-8.2, conductivity 235 umh/cm. The main fish species living in the same localities were *Alburnoides bipunctatus*, *Acanthobrama marmid*, *Barbus rajanorum*, *Capoeta trutta*, *Carasobarbus luteus*, *Garra rufa*, *Mastacembelus simack* and *Mystus halepensis*.

MATERIALS AND METHODS

A total of 480 specimens (263 females and 217 males), fork length (FL) ranging from 103 to 192 mm, were caught from October 1990 to February 1992. The sampling was made by gill-nets of various mesh-sizes (18, 24 and 30 mm). Fork length and weight were measured to the nearest 1.0 mm and 0.1 g, respectively. Sagitta otoliths were used for age determination: they were cleaned, dried and examined under a binocular microscope. The sex was determined by examination of the gonad tissue either by the naked eye for big specimens or with the aid of a stereomicroscope for small ones.

Sex ratio for the entire sample and for each age group was tested using a χ^2 test for significant differences from an expected 1:1 ratio. An α level of 0.01 was used to determine significance.

The formulas, $L_t = L_\infty [1\text{-}e^{-k(t\text{-}to)}]$ and $W_t = W_\infty [1\text{-}e^{-k(t\text{-}to)}]^n$, were used to determine the age-length and age-weight relationships, respectively (von Bertalanffy, 1938); where L_t = fork length at age t, L_∞ = asymptotic length, k = growth coefficient, t_o = theoretical age at zero length, W_t = weight at age t, W_∞ = asymptotic weight. The length-weight regression equation was carried out by the least squares method on logarithmic transformed data by the formula $W = aL^n$ (Le Cren, 1951). Analyses of variance (ANOVA) were carried out to determine the statistical significant in the length-weight relationships. The value of the exponent 'n' was tested against the value '3' by Student's t test. Total fish weight was used to determine the relative condition index (I_c) from the equation: $I_c = W/W'$ where W' is the expected weight of the same length estimated by the formula $W = aL^n$ for female, male and combined sexes (Le Cren, 1951; Tesch, 1968; Weatherley, 1972). The Kruskal-Wallis ANOVA was used to test for differences in relative condition index and GSI between months. Statistical differences between female and male in lengths and in relative condition index were determined using Student's t-test (Simpson *et al.*, 1960). The least significant differences was $p < 0.05$.

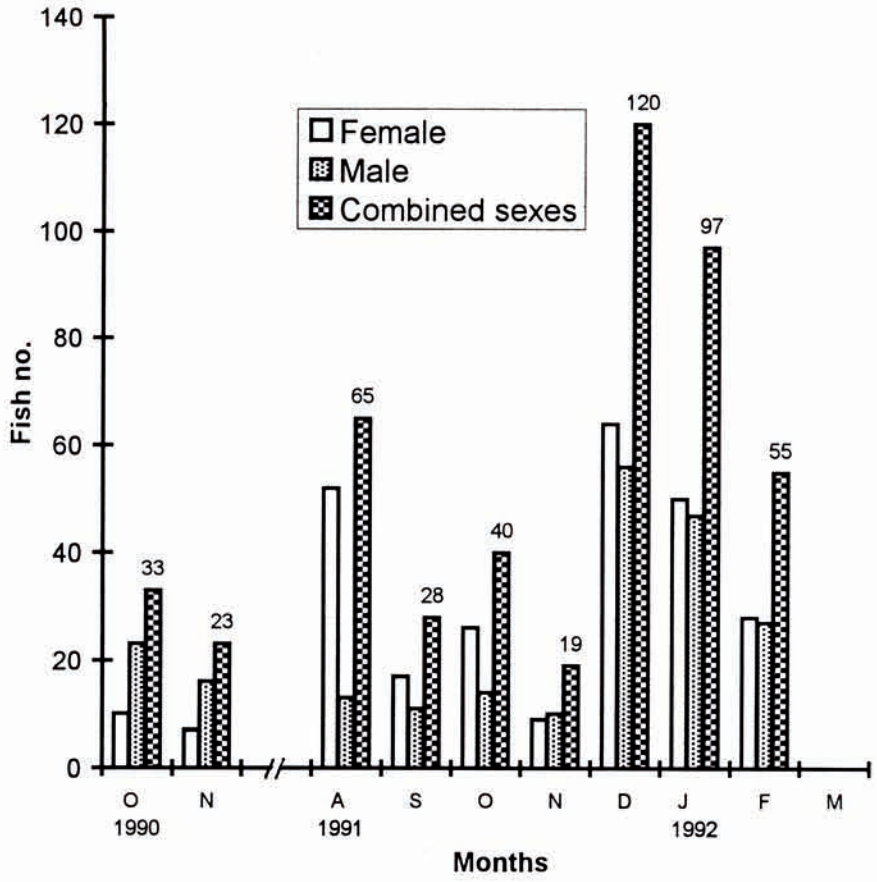

Fig. 2. - Sample frequency of *Liza abu* in the Tigris River during the study period Oct. 1990 - Feb. 1992.

Gonads were removed and weighed to the nearest 0.01 g and the ovaries preserved in a 4% formalin solution. The gonado-somatic index (GSI) was calculated as follows: GSI = 100 Gonad weight / Body weight - Gonad weight (Ntiba and Jaccarini, 1990).

The staging of gonads as immature (I), resting (II), early ripening (III), late ripening (IV, for female only), ripes (V, for females and IV, for males), spent (VI, for females and V, for males) follows the criteria of Naama *et al.* (1986).

Females (n = 107) ranging from 117 to 192 mm, and males (n = 137) from 115 to 188 mm were used to calculate lengths at first maturity. Size at first maturity was defined as the length at which 50% of the specimens had already matured at least once (stages III, IV and V), in comparison with individuals that had not reached maturity yet, corresponding to stages I and II (Babiker and Ibrahim, 1979; Mattson and Kaunda, 1997).

Fecundity (F) was estimated from 51 ripe females obtained between December 1991 and February 1992 by counting all their ripe oocytes by the gravimetric method (Libosvarsky, 1979). The procedure was as follows: after two to three hours of washing, the ovaries were put on a filter paper to get rid of excess moisture. Next, the whole ovary and a sample of it, taken from middle part of the gonad, were weighed and the oocytes in

the sample were counted. Relative fecundity (F_r) was calculated as $F_r = F / W - GW$. All the parameters were estimated for each fish, then grouped in age classes for analysis. The diameters of ripening oocytes were also measured. About fifty oocytes selected at random from each ovary were measured by means of a micrometer eye-piece and the mean oocyte diameter was then computed for the entire sample. The relationships fecundity (F)-fork length (FL), fecundity-body weight (W) and fecundity-gonad weight (GW) were carried out by using the least squares method on logarithmic transformed data (Pantulu, 1963; Pitcher and Macdonald, 1973).

$$\log F = \log a + b \log FL$$
$$\log F = \log a + b \log W$$
$$\log F = \log a + b \log GW$$

Statistical analyses were undertaken using Statistica for Windows Release 4.5, and Microsoft Excel for Win'95 Version 7.0.

RESULTS

Migration

Liza abu samples were caught only between August and February when this fish is abundant in the river during the study period (Fig. 2).

It is under possibility to move towards upstream of the Tigris River during the period between August and February. Most probably, the climatic conditions in other sections of the river spent the fish migrating here to feed and to recover. A large number of

Table I. - The samples of *Liza abu* caught from the Tigris River during the study period, Oct. 1990-Feb. 1992. N: Number of females (F) and males (M). Minimum and maximum values are given in parentheses.

Date	N F : M	Mean ± S.D. FL Female	Mean ± S.D. FL Male
Oct. 1990	10 : 23	156.30 ± 12.10 (140 - 173)	154.13 ± 9.98 (135 - 172)
Nov. 1990	7 : 16	142.00 ± 10.28 (130 - 160)	147.50 ± 10.83 (133 - 169)
Aug. 1991	52 : 13	157.77 ± 11.30 (135 - 183)	149.92 ± 12.16 (131 - 174)
Sep. 1991	17 : 11	163.70 ± 10.83 (141 - 178)	167.18 ± 11.59 (148 - 187)
Oct. 1991	26 : 14	160.57 ± 14.48 (133 - 192)	154.93 ± 17.31 (125 - 188)
Nov. 1991	9 : 10	165.44 ±18.40 (135 - 187)	160.50 ± 6.24 (151 - 172)
Dec. 1991	64 : 56	133.94 ± 8.64 (116 - 157)	132.52 ± 14.31 (103 - 168)
Jan. 1992	50 : 47	136.94 ± 12.24 (115 - 170)	137.02 ± 18.09 (106 - 180)
Feb. 1992	28 : 27	144.61 ± 19.38 (118 - 188)	150.41 ± 19.60 (117 - 187)

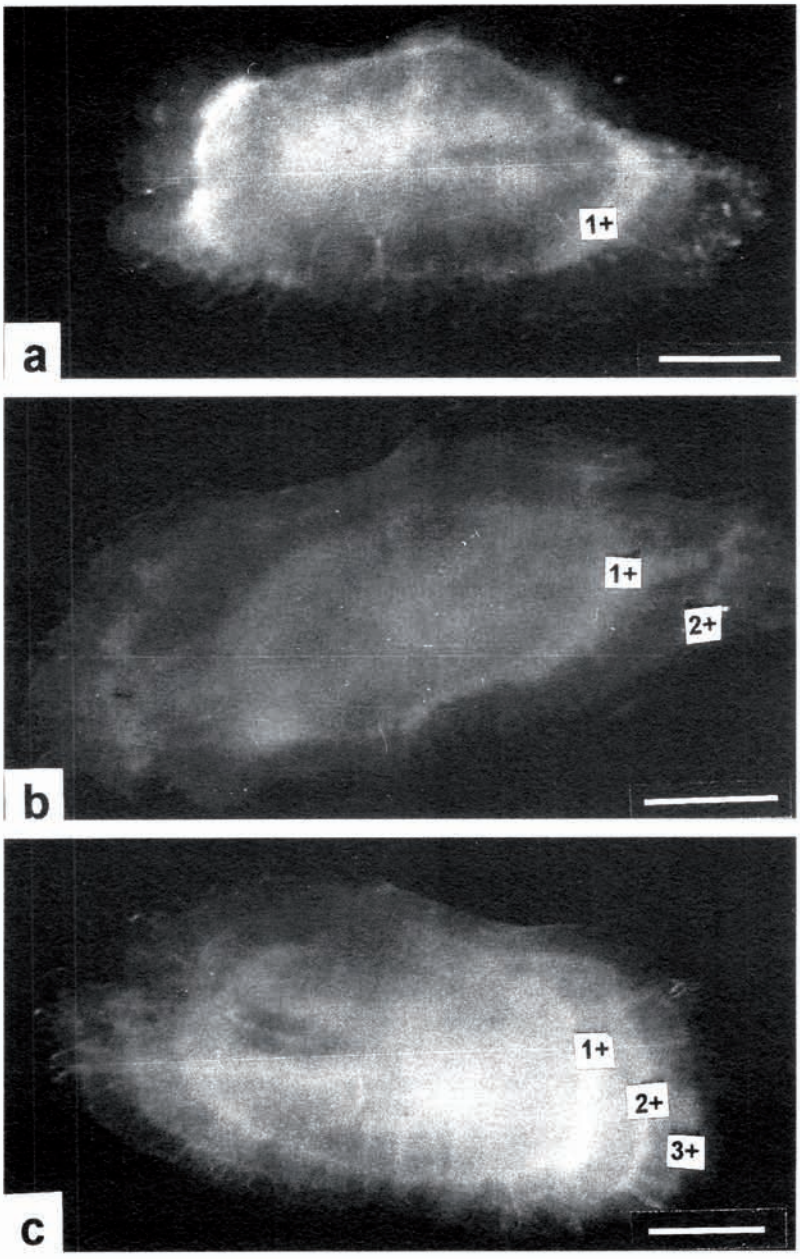

Fig. 3. - Otoliths of *Liza abu*. **a**: 1+, 122 mm FL; **b**: 2+, 134 mm FL; **c**: 3+, 168 mm FL ages. Scale bar = 1 mm.

specimens was caught during this period by fishermen of the Diyarbakir province. From the end of February, *L. abu* starts to return towards the back downstream of the river. The

number of specimens caught from the Tigris River during the study period, Oct. 1990-Feb. 1992, is shown in table I.

The otoliths

The use of sagitta otoliths for estimating age proved straightforward for *Liza abu*, and both otoliths from the same fish were generally readable. The opaque and translucent increments were clearly visible on whole otoliths from samples when viewed whole in reflected light (Fig. 3). The outer edge of all otoliths examined show a translucent zone corresponding to the October-February period between 1990 and 1992. Due to the lack of data for spring and summer seasons, it was impossible to determine the translucent zone in samples belonging to mentioned seasons. Most probably, translucent zones are formed in the otoliths of *L. abu* during autumn and winter seasons. Only one translucent zone was visible in the otoliths of 1+ age. Two translucent zones for 2+, three translucent zones for 3+, etc. The length of the otoliths varied from 3 to 5.9 mm. Typical otoliths belonging to 1+, 2+ and 3+ ages are shown in figure 3.

The ages of the 480 specimens examined (263 females and 217 males) ranged between 1+ and 4+. There was not any specimen examined as age group 0 and over the age group IV.

Sex ratio

The obtained sex ratio for each age groups are given in table II. The sex of small individuals could be determined on undeveloped gonads by using a stereoscopic binocular microscope.

The sex distribution frequency shows a marked deviation from a 1:1 expected sex ratio (Table II). The observed sex ratio was 1.21 females for one male. Sex ratio was significantly different from 1:1 (χ^2, $p < 0.01$) in the age groups IV, while no significant differences were found from the 1:1 sex ratio (χ^2, $p > 0.05$) in the other age groups. A greater sex ratio at males was seen only in age group II (0.89 female: 1 male).

Growth in length

The mean lengths between females and males *Liza abu* are different at all age groups (Table III), but only the differences between age-groups I and II are statistically significant (Student's t-test; $p < 0.01$). Von Bertalanffy growth equation values for L_∞ (mm), K and t_0 were given for females, males and combined sexes separately (Table IV). The female had high L_∞, but low K value whereas the L_∞ for male were lower, but the K value was higher. The von Bertalanffy equations, when superimposed on the length at terminal age data (Table III), indicated that in both sexes the obtained lengths are shorter than their theoretical maxima (L_∞).

Table II. - Sex ratio of *Liza abu* from the Tigris River. N: Number of samples.

				Sex ratio		
Age groups	Female	Male	Total	Female %	Male %	Female : Male
I	129	91	220	58.6	41.4	1.42 : 1
II	54	61	115	47.0	53.0	0.89 : 1
III	60	57	117	51.3	48.7	1.05 : 1
IV	20	8	28	71.4	28.6	2.50 : 1
Total	263	217	480	54.8	45.2	1.21 : 1

To assess the total length (TL) - fork length (FL) ratio, the TL and FL relationship were calculated as follows:

Female: $TL = -3.4586 + 1.057 * FL$, $(r^2 = 0.996)$
Male: $TL = -2.2418 + 1.050 * FL$, $(r^2 = 0.985)$.

Growth in weight

The mean weights between females and males are different at all age groups (Table V), but only the differences between age-groups I and II are statistically significant (Student's t-test; $p < 0.01$).

Von Bertalanffy growth equations for weight are expressed as follows: $W_t = 124.67[1-e^{-0.304531(t+2.507883)}]^{3.4417}$ for females, $W_t = 106.84[1-e^{-0.513397(t+0.855108)}]^{3.2162}$ for

Table III. - Lengths (mm) of the different age groups of *Liza abu* from the Tigris River. N: Number of fishes; FL: Fork length; SD: Standard deviation; CV: Coefficient of variation. Minimum and maximum values are given in parentheses.

Age groups	N F : M	Mean ± S.D. Female	Mean ± S.D. Male	CV F : M	Significance level
I	129 : 91	132.84 ± 6.96 (115 - 152)	127.12 ± 8.09 (103 - 146)	5.24 : 6.36	$p < 0.01$
II	54 : 61	153.04 ± 8.16 (135 - 171)	152.51 ± 8.87 (131 - 173)	5.33 : 5.81	$p > 0.05$
III	60 : 57	161.77 ± 12.04 (130 - 183)	159.88 ± 11.72 (135 - 188)	7.44 : 7.33	$p > 0.05$
IV	20 : 8	176.25 ± 7.91 (162 - 192)	175.63 ± 10.13 (157 - 187)	4.49 : 5.77	$p > 0.05$

	L_∞	K	t_0
Female	204.27	0.304531	-2.507883
Male	198.98	0.513397	-0.855108
Combined sexes	195.77	0.383129	-1.955000

Table IV. - Von Bertalanffy growth curve parameters for female, male and combined sexes of *Liza abu* from the Tigris River.

Table V. - Weights (W, g) of the different age groups of *Liza abu* from the Tigris River. See table II for abbreviations.

Age groups	N F : M	Mean ± S.D. Female	Mean ± S.D. Male	CV F : M	Significance level
I	129 : 91	28.80 ± 5.95 (17 - 64)	25.21 ± 4.82 (12 - 38)	20.68 : 19.21	$p< 0.01$
II	54 : 61	50.61 ± 8.28 (33 - 68)	47.18 ± 8.82 (29 - 63)	16.32 : 18.69	$p< 0.05$
III	60 : 57	57 - 40 ± 13.98 (32 - 92)	53.60 ± 13.10 (30 - 92)	24.35 : 24.44	$p> 0.05$
IV	20 : 8	76.95 ± 11.03 (61 - 98)	75.00 ± 13.01 (58 - 97)	14.34 : 17.34	$p > 0.05$

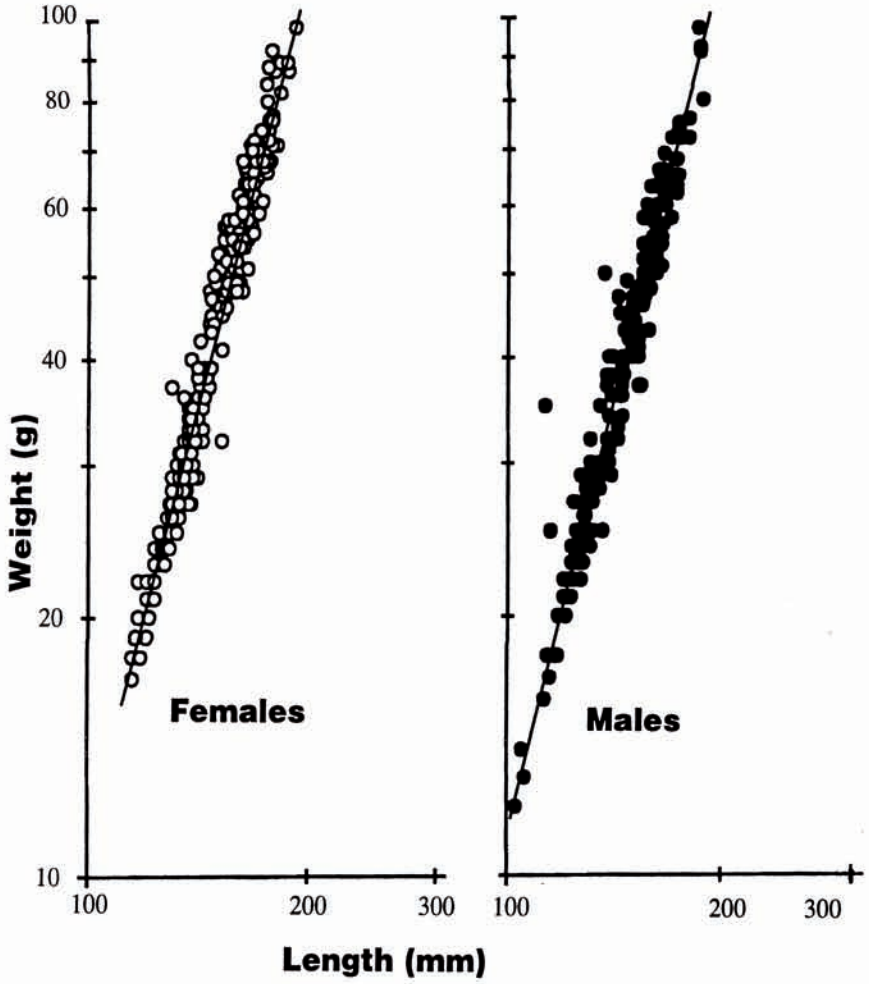

Fig. 4. - Logarithmic length - weight relationship of *Liza abu* from the Tigris River. The points represent the data obtained from the fish and the solid lines represent estimated length - weight relationship based on the equations given in the text.

males and $W_t = 104.91[1-e^{-0.383129(t+1.95500)}]^{3.3315}$ for combined sexes. W_∞ of female was higher than the value of male. The maximum weight data (Table V) obtained for both sexes were found to be lower than the estimated theoretical maxima (W_∞).

Length-weight relationship

Separate length (FL) - weight (W) relationships were calculated by using the method of least squares on log(FL) and log(W) and gave the following results (Fig. 4):

log W (female) = -5.8488 + 3.4417 logFL (r^2 = 0.952)
log W (male) = -5.3649 + 3.2162 logFL (r^2 = 0.941)
log W (combined sexes) = -5.6169 + 3.3315 logFL (r^2 = 0.946)

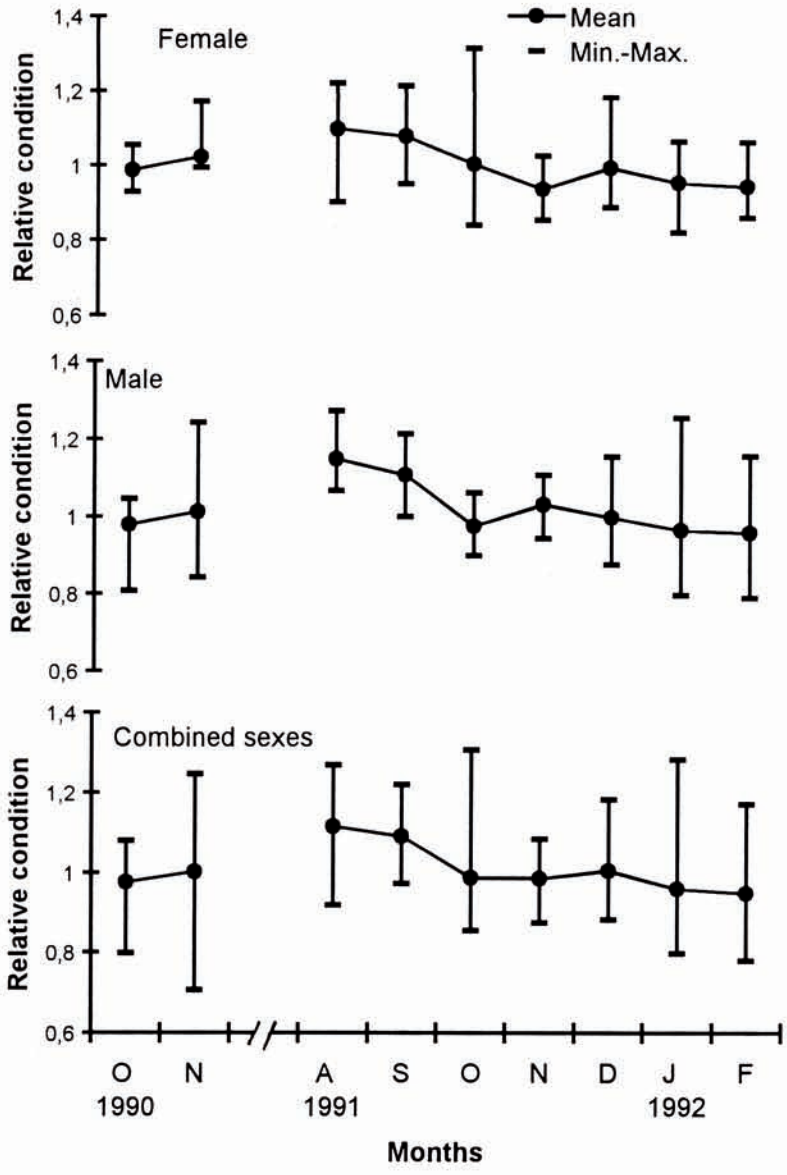

Fig. 5. - Monthly fluctuation in the relative condition of *Liza abu* from the Tigris River.

Linear regressions on log-transformed data were highly significant (ANOVA, $p < 0.001$) for both sexes. The value of the exponent 'n' estimated for both female and male were significantly different from the value '3' (Student's t-test, $p < 0.001$). These proved to be allometric growth patterns in *L. abu*.

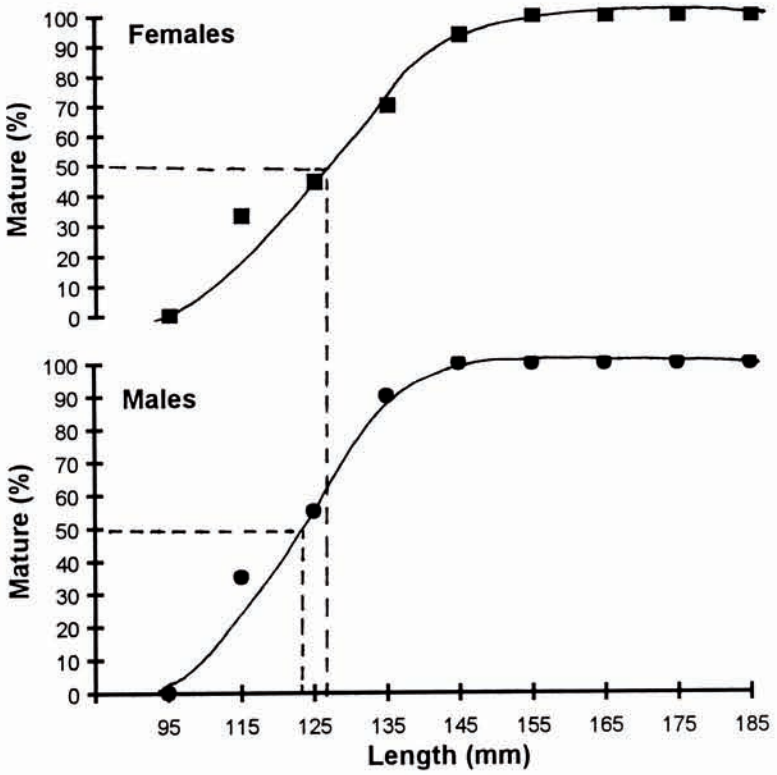

Fig. 6. - Percentage of mature *Liza abu* from the Tigris River. Dotted lines indicate the lengths at first maturity, the size at which 50% of fish are mature. Solid lines fitted by eye.

Table VI. - Relative condition indexes of the different age groups of *Liza abu* from the Tigris River. See table II for abbreviations.

Age groups	N F : M	Mean ± S.D. Female	Mean ± S.D. Male	Mean ± S.D. Combined sexes	Significance level between female and male
I	129 : 91	1.00 ± 0.07 (0.89 - 1.31)	0.98 ± 0.07 (0.80 - 1.26)	1.01 ± 0.07 (0.88 - 1.18)	$p > 0.05$
II	54 : 61	1.07 ± 0.09 (0.86 - 1.22)	1.03 ± 0.11 (0.79 - 1.27)	1.10 ± 0.09 (0.80 - 1.27)	$p < 0.05$
III	60 : 57	0.99 ± 0.09 (0.70 - 1.20)	1.00 ± 0.08 (0.85 - 1.19)	1.02 ± 0.09 (0.70 - 1.20)	$p > 0.05$
IV	20 : 8	1.01 ± 0.09 (0.85 - 1.19)	1.04 ± 0.05 (0.93 - 1.16)	1.03 ± 0.08 (0.87 - 1.19)	$p > 0.05$

Relative condition index

The relative condition indexes (I_c) for both females and males showed significantly differences between months and between age groups (Kruskal-Wallis ANOVA, $p < 0.001$). Both sexes followed the same general trend of changes in I_c throughout most

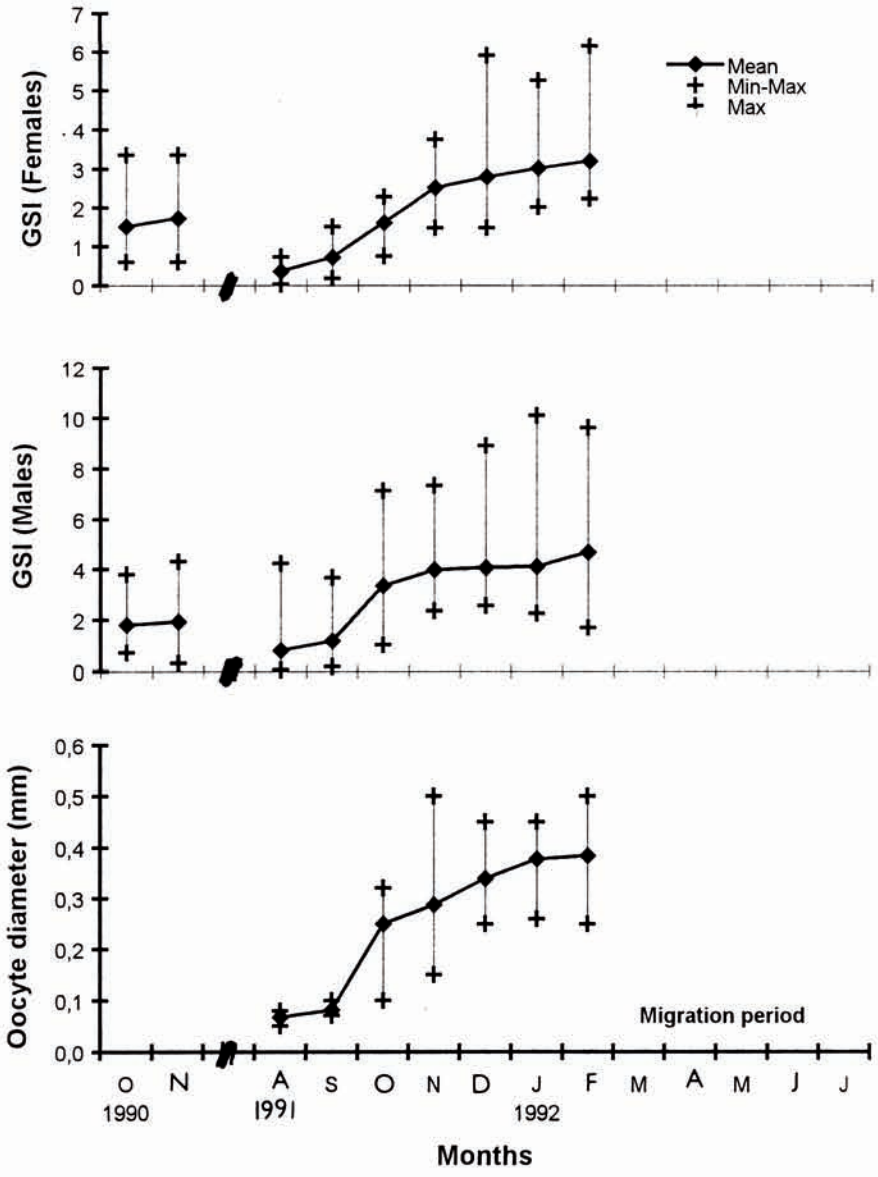

Fig. 7. - The monthly GSI values and oocyte diameter of the *Liza abu* from the Tigris River.

of the year. The highest value was recorded in the August, while the lowest in the October for females and November for males (Fig. 5).

Mean I_c values of females were not significantly different of those of males in same age groups, except age group II (Student's t-test, $p < 0.05$) (Table VI). The mean I_c

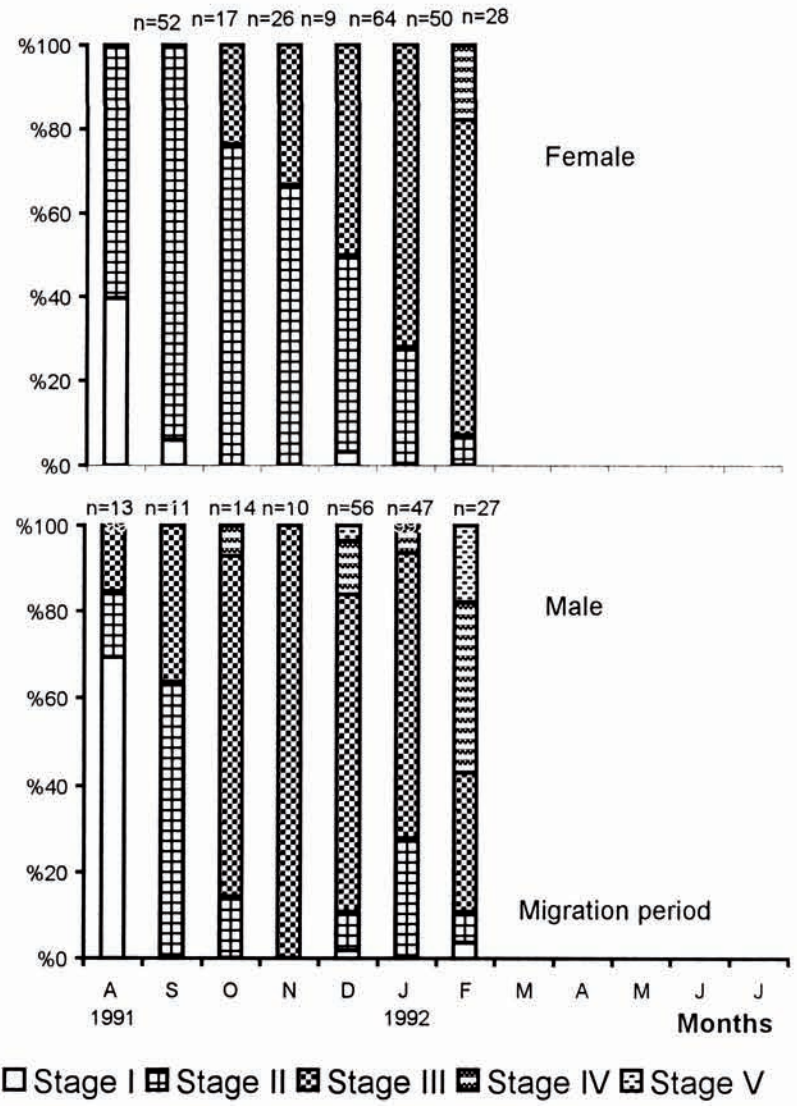

Fig. 8. - Monthly changes in the maturity stages of the *Liza abu* from the Tigris River.

values for all of females and males were 1.004 ± 0.089 and 1.000 ± 0.087 respectively, and the difference was not found significant (Student's t-test, $p > 0.05$).

Age and length at sexual maturity

Male matured at a shorter length than female. Fifty% maturity occurred at approximately 124 and 127 mm FL for females and males, respectively (Fig. 6). The smallest mature female was 117 mm FL and 17 g in total weight, and male 115 mm FL and 14 g in total weight; 100% maturity was attained at 155 mm in female and at

145 mm in male. The length at first sexual maturity was found to correspond to an age of one year for both sexes.

Gonad weight and gonado-somatic index

For both sexes, increasing of gonado-somatic index (GSI) begins in October and continues during the following months (Fig. 7). The GSI values showed significantly differences between months for both females and males (Kruskal-Wallis ANOVA, $p < 0.001$). There were marked individual variations in the pattern of monthly GSI values, as shown by the vertical columns that represent the maximum and minimum values. The mean oocyte diameter was the smallest in August when the ovaries contain only oocytes which will develop the following year; the highest diameter was attained in February (Fig. 7). The maximum weight was 4.6 g for ovaries and 5.5 g for testes and maximum GSI value was 6.15 (females) and 10.01 (males).

Four maturity stages were distinguished for the females and five for the males. The monthly distribution of the maturity stages of both sexes in the period from August 1991 to February 1992 is shown in figure 8. No females at over stage IV and males at over stage V were caught during the study period indicating that spawning does not take place in the upstream of Tigris River.

Fecundity

The number of ripe oocytes of 51 females at maturity stages III and IV ranged from 12,175 (139 mm FL specimen) to 56,400 (178 mm FL specimen). The mean was 21,641. The absolute (F_a) and relative fecundity (F_r) are given in table VII. The number of oocytes increased with fish length (L), and were positively correlated with fish weight (W) and gonad weight (GW). The logarithmic equations are given in table VIII. Fecundity increased exponentially with fish length-weight and gonad weight. The correlation coefficient of fecundity with gonad weight was lower than that of fecundity with fish weight

Table VII. - Absolute (F_a) and relative (F_r) fecundity of the different age groups of *Liza abu* from the Tigris River.

Age groups	N	F_a	F_r
I	27	16704.04 ± 6188.94 (12175 - 34611)	606.93 ± 268.93 (405.60 - 1466.57)
II	10	30875.20 ± 3584.80 (27300 - 38200)	639.08 ± 84.67 (555.77 - 820.10)
III	8	40493.67 ± 9549.80 (28462 - 56250)	662.52 ± 157.80 (442.64 - 849.62)
IV	6	43475.83 ± 9549.80 (28462 - 56400)	588.90 ± 63.98 (519.74 - 686.93)

Table VIII. - Fecundity-length, weight and gonad-weight relationship parameters of *Liza abu* (N = 51) from the Tigris River.

Fecundity - length relationships				Fecundity - weight relationships				Fecundity - gonad weight relationships			
log a	b	r^2	Significance level	log a	b	r^2	Significance level	log a	b	r^2	Significance level
- 2.304	3.071	0.651	$p < 0.001$	2.8274	0.9586	0.677	$p < 0.001$	4.3675	0.5533	0.516	$p < 0.001$

and length. But the relationship between fecundity and the fish weight and length and gonad weight were significant (ANOVA, $p < 0.001$). That means that there is a clear trend of increasing oocyte number with fish length, weight and gonad weight.

DISCUSSION

Although all *Liza* species spawn in the sea and feed mostly in fresh water, there is no evidence that *Liza abu* spawn in the sea. It was reported that *L. abu* remains continually in fresh water (Beckman, 1962; Naama *et al.*, 1986) but, this fish was recorded at Kishni, in Iraqi marine waters, north-west of the Arabian Gulf (Nasir and Naama, 1988). Also, it is not evident that this species spawn in the Tigris River, Turkish area.

The present study of 480 *L. abu* from the Tigris River shows that 54.79% are females and 45.21% males ranging between I-IV age groups. Al-Nasiri and Sirajul Islam (1978) have recorded only age groups 0+ to 2+, while Mhaisen and Al-Jaffery (1989) have determined six age groups in Babylon Fish Farm. Otoliths rings of younger age groups were much clearer and more easily identifiable than in the older age groups, as observed by Al-Nasiri and Sirajul Islam (1978). The sex ratio was found to be 1.21 females: 1 male in the studied samples, as in the Al-Hammar Marsh (1.3:1, Naama *et al.*, 1986). The domination of age group I for both females and males may be due to our fishing method.

The total lengths of each age group calculated from TL-FL relationships were found to be similar to those of the samples from Iraq (Al-Nasiri and Sirajul Islam, 1978; Mhaisen and Al-Jaffery, 1989).

The mean I_c values of females were not significantly different with those of males for all age groups excepted for age group II. *L. abu* had significantly higher I_c values from August to September, when the minimum GSI values were observed, than in other months. Concomitant GSI increases and decreases in I_c values may be caused by the depletion of body reserves (Sayer *et al.*, 1996).

Using the gonado-somatic index (GSI) values, oocyte size and direct observation of gonad maturity of *L. abu* population in the Tigris River, we have tried to determine spawning time in this species. The gonad weight and oocyte diameter increased gradually from the beginning of September to February. However, because the lacking of samples due to migration from upstream to downstream for successive months, it was not possible to determine exactly the spawning period for *L. abu* from Tigris river. Naama *et al.* (1986) recorded the spawning time of *L. abu* between November and March. Our samples from November to February revealed stage IV in females and stages IV and V in males. The climatic conditions, such as the high temperature in the region of Al-Hammar marsh, may result in early spawning time. Similar early spawning time was also recorded for *Mugil parsia* in Indian waters at which summer season occurs early (Sarojini, 1957). The spawning of most mugilids in the Black Sea and the Mediterranean occurs during summer, from June to September (Erman, 1959; Erman, 1961; Yerli and Erk'akan, 1990; Demirkalp-Aksun, 1992). The state of the gonads through the studied period indicates that the spawning of *L. abu* can not take place before March in a still unknown place in the Tigris River. Beckman (1962) also recorded that *L. abu* spawn in spring in the Khabour River (Syria).

Our results indicate that *L. abu* mature at the end of their first year of life in the Tigris River. A similar result was observed by Naama *et al.* (1986) and by Al-Yamour *et al.* (1988) in Iraq populations. Results obtained by many workers show that, generally,

larger mugilids attain sexual maturity at larger lengths and older ages (Erman, 1959; Erman, 1961; Yerli and Erk'akan, 1990; Demirkalp-Aksun, 1992).

The fecundity of *L. abu* was positively correlated to length, weight and gonad weight as for many fish species (Pantulu, 1963; Lobon-Cervia and Fernandez-Delgado, 1984; Ünlü and Balci, 1993; Ünlü *et al.*, 1994). There was no data on fecundity of *L. abu* previously in the literature. However, the eggs number of *L. abu* from the Tigris River was very low compared to those reported for other mugilids. Salem and Mohammed (1982) stated that the egg number averaged 261 thousands for *M. seheli* and 981 thousands for *M. capito*. Wijeyaratne and Costa (1987) estimated that the eggs number to be 12,300-9,555,000 for *L. macrolepis* ranging in total length from 16 cm to 30 cm. The eggs number ranged between 133,224-295,065 for of *L. subviridis* ranging from 182 to 243 mm total length (Al-Daham and Wahab, 1991).

Oocytes were observed at all seasons. During the study period, the mean egg diameter was the smallest in August, while the highest was measured in February. Naama *et al.* (1986) showed that the mean egg diameter ranged from 0.1 to 0.70 mm in the Al-Hammar marsh population (Iraq) and all the oocytes measured as 0.70 mm and above, were assumed to be fully ripe; on the contrary, in the samples of *L. abu* investigated in the Tigris River, the egg diameter ranged between 0.05 and 0.5 mm and they were not fully ripe. This result indicates that the egg of samples of *L. abu* studied may be ripe after migration.

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